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The Birmingham (Lucas) pacemaker
An appraisal of its use

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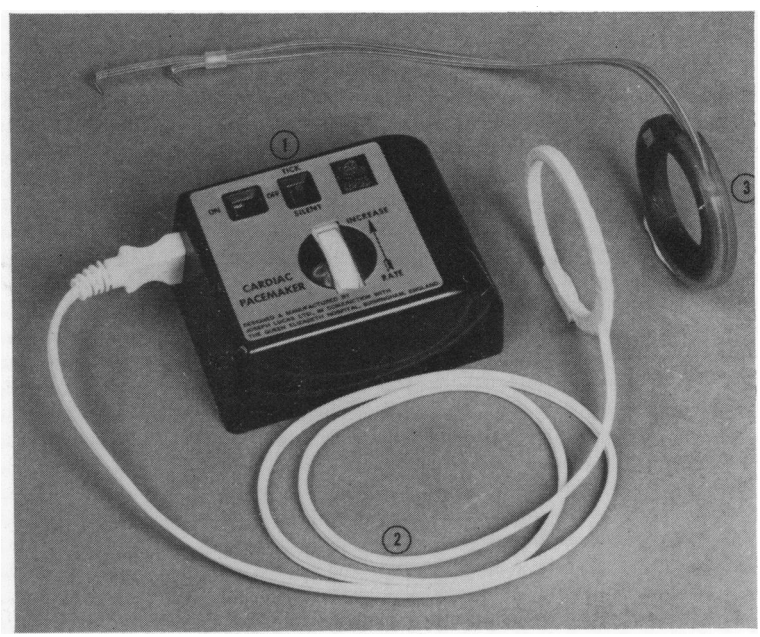
The results of 64 patients pacemade by the Birmingham (Lucas) inductive system are described. As in other series, thoracotomy and epicardial wires carried a higher postoperative mortality but a lower incidence of reoperation than did the lesser operation of catheter-coil insertion. Muscle twitch was a minor but annoying complication of the latter operation. The advantages and disadvantages of this system as compared with totally implanted units are discussed. It is considered to be more reliable (fewer reoperations) and to have other advantages including the facility to use high voltage stimulation in emergency. An elaborate follow-up system to detect early generator failure is unnecessary. Its major disadvantage is psychological and, in retrospect, 12·5 per cent of patients were unsuitable to be pacemade by this method on these grounds. Nevertheless, it is a safe and otherwise very satisfactory form of long-term pacemaking.

Use of the Birmingham (Lucas) type inductive pacemaker for the treatment of chronic heart block was first described by Abrams, Hudson, and Lightwood (1960). Since that time it has been extensively used in Birmingham and elsewhere. Nevertheless, reports on its use are sparse, and there is no critical comparison in the published reports between it and the more widely used totally implanted systems. The Lucas system has been used in Sheffield since 1966 – pacemakers being inserted at thoracotomy until 1968 and by endocardial catheter since that time. All pacemade patients have been carefully followed and complications of each method of insertion recorded. This paper compares the fate and problems of each set of patients and discusses the relative merits and disadvantages of the Lucas system as compared with totally implanted units.

Description of the unit

The external generator (Fig. 1) is a rectangular plastic box 9·4 cm × 7·2 cm × 4·1 cm. On its face are the external controls consisting of two recessed switches and a large knurled disc. Rotation of the disc determines the rate of impulse generation. One switch is on and off for the unit, and the other determines whether the unit generates an audible signal per stimulus delivered. The reverse face of the generator is divided into two unequal halves. The smaller contains the power source – a U2 torch battery – which is readily accessible via a sliding cover. The other half contains the voltage converter circuitry, capacitator, and a switch whereby the generator can be set to deliver energy at either high or low

FIG. 1 *External generator. 1. Pulse generator. 2. External coil and lead. 3. Internal coil.*



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power. This half is protected by a plastic cover secured by four plastic screws.

Battery life is approximately one month on low and one week on high power. As the battery is used the discharge rate in the circuitry slows. This is corrected by the patient rotating the rate control disc on the front of the generator, thereby giving him an indication of remaining battery life. Patients are taught to change generators at stated time intervals and by this means impulse voltage remains constant over the period of battery use. This voltage is not dependent upon pulse rate or upon battery charge until total battery exhaustion.

The lead to the external (primary) coil is connected to the side of the generator by a push-pull fit. Should this fit be inadequate or the lead be broken, the generator will emit an easily audible warning buzz – provided it be set at TICK. Lead length is 35·5 cm, while the adult external coil is 6·3 cm in external diameter and 0·5 cm thick.

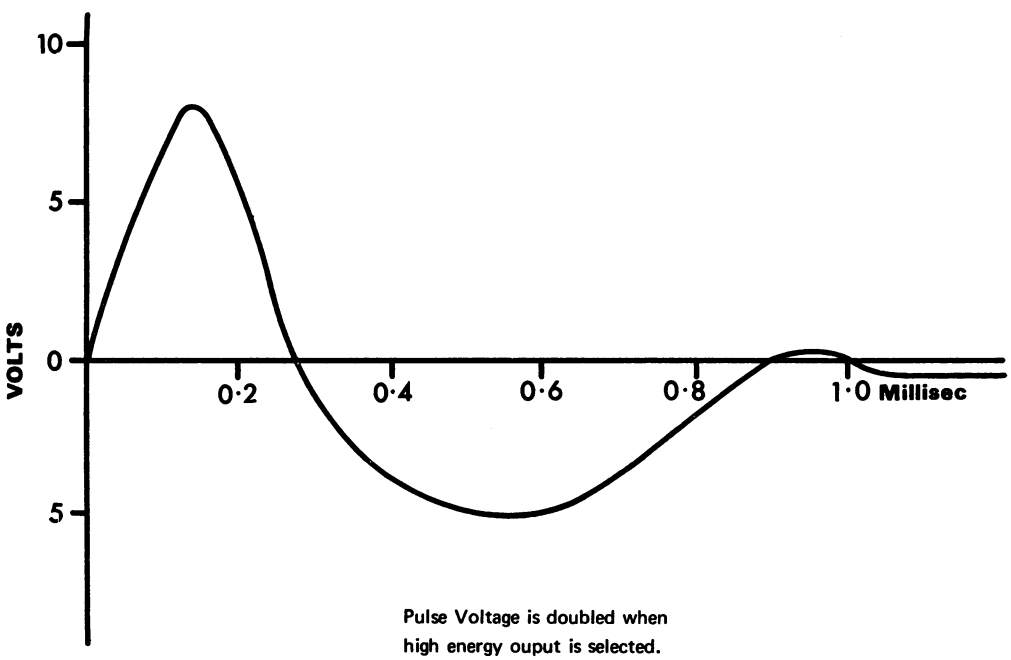
The external coil overlies the subcutaneously implanted internal (secondary) coil, energy being induced across the intact skin. This secondary coil consists of a thousand turns of copper wire encased in silicone rubber. It is usually implanted just below the clavicle when using endocardial catheters or rather lower on the left chest when using epicardial wires. Secondary coils are of two types, being provided either with two electrodes for myocardial implantation or with two short leads for catheter connexion. Of the two leads one has a simple pin terminal fitting the catheter by a self-sealing push fit. The other lead terminates in the indifferent electrode attached to sternal periosteum. The indifferent electrode itself is a small loop of approximately 60 mm^2 in surface area.

All of these leads and the catheter are made of stainless steel wound from three strands as a triple helix. The catheter itself is unipolar and platinum tipped. Manipulation of this catheter is via a steel stylet which is withdrawn when a suitable position has been found. Normally supplied catheter length is 80 cm but it can readily be cut to any suitable size without prejudicing its fit to the internal coil.

Fig. 2 shows the characteristics of the impulse delivered to the heart. Pulse width is normally 1 msec but can be altered by increasing or reducing the number of turns in the external coil. The voltage waveform is in the shape of a biphasic sine wave with approximately equal curve areas around zero. Delivered voltage is determined by two factors: the position of the low-high power switch, and the lateral or vertical separation of the two coils. Except in special circumstances patients are taught to maintain these two coils in the closest possible opposition using adhesive tape on the skin.

Before discharge from hospital all patients are given an instruction leaflet describing the pacemaker and its use. They and one relative where possible are taught about the pacemaker and how to look after it including such simple procedures as changing of batteries and of the external coil. All patients are normally pacemade on low power.

FIG. 2



Stimulating pulse form. Coils at 1 cm separation heart load 180 ohms

Patients and methods

Between March 1966 and July 1970 a total of 64 patients have been pacemade by the Lucas system. There have been 34 men and 30 women whose ages ranged between 34 and 85 years at operation (mean 64·8). Of these, 53 patients had complete heart block, 9 had varying block, 1 had sinus arrest, and in 1 patient a pacemaker was inserted in an attempt to prevent recurrent ventricular arrhythmias due to alcoholic cardiomyopathy. The aetiology of the bradycardiac arrhythmias was unknown in 37 patients. In 11 there was definite proof of ischaemic heart disease, and this was suspected in a further 12. Rheumatic heart disease accounted for 2 cases and congenital heart block for 1. Associated relevant diseases were past systemic hypertension in 6 patients, a history of rheumatic fever in 6, diphtheria in 2, and clinically obvious aortic valve disease in 1.

Symptoms had been present in all patients, the time varying from many years to a few days. Adams-Stokes seizures had been sustained by the majority (54 patients), the remainder having symptoms attributable to a low cardiac output. Medical therapy for heart block had been attempted in at least 44 patients, usually being terminated because of lack of effect.

Thirty-six early patients were pacemade by thoracotomy and epicardial wires, mean operation age for this group being 61·3 years. At operation wires were sutured onto the right ventricle on 14 occasions, onto the left on 13, and in 9 patients it has not been possible to determine which ventricle was used. All patients who left hospital except 8 were discharged on low power. In only one of these 8 has it since been possible to reduce stimulus strength to low power.

Since November 1968, 30 patients have been pacemade by use of the jugular veins and endocardial catheters (this figure includes 2 patients whose original pacemakers failed). Mean operation age for this group was higher at 68·9 years. The right external jugular has been the vein of choice (28 patients) but on two occasions has been unsuitable because of tortuosity necessitating the use of the right internal and the left external jugular vein on one occasion each. Catheters have been wedged in the apex of the right ventricle and satisfactory radiological and electrical positions obtained. All these patients have been discharged and maintained on low power.

Results

Epicardial wires Of the 36 patients, 23 are still living and in 20 the original implanted unit is still functioning satisfactorily, having been in continuous use for between 22 and 51 months (mean 33·6). Of the 13 deaths, 8 patients died in hospital within three weeks of thoracotomy. The causes of death were arrhythmia (3 patients), postoperative chest complications (3 patients), myocardial infarction (1 patient), and low output syndrome (1 patient). Of the late deaths all except one occurred outside hospital. Four patients died suddenly (1, 12, 25, and 45 months from operation), and it is assumed that these deaths were caused by arrhythmias – confirmed on one occasion by hospital death. One patient committed suicide at 12 months.

It has not been possible to determine whether high power pacing was a factor in precipitating arrhythmic death. However, one patient, whose pacemaker was successfully changed from low to high power because of 'missing' at 5 days, died from ventricular fibrillation the next day.

There have been 3 internal unit failures, 2 of these occurring late (20 and 23 months). For one of these no cause was found, but since the epicardial coil was not removed it could have been due to wire fracture. This patient had been on high power since operation. The second patient did temporarily respond to being changed to high power stimulation and electrocardiographs suggested exit block. Both these patients have been satisfactorily transferred to endocardial systems.

Infection was a problem in 4 patients. In 2 it was a contributory factor to death, while in a third it was necessary to remove the coil before it could be controlled, this being the third internal unit failure. In the fourth patient eventual wound healing was achieved by medical measures.

There have been no other complications specific to thoracotomy except that in 2 patients the internal coil was placed rather deep to breast tissue making apposition of the external coil difficult.

Overall mean patient survival time currently stands at 24·0 months, and this compares with a mean internal unit survival time of 22·9 months.

Endocardial catheters Of the 30 patients pacemade by this method, 29 are still alive and in 23 the original implanted unit is still functioning satisfactorily, the longest lasting being that of the first patient pacemade for 19 months. The one patient died 2 days after operation. The actual mode of death was arrhythmic but necropsy disclosed a 250 ml haemopericardium corresponding to a catheter perforation of the right ventricle. This perforation had been noted during the period of earlier temporary catheter pacemaking, but at manipulation of the permanent catheter (stiffened by the guide wire along its length) it was noted to enter the pericardial sac before a satisfactory position was obtained.

Reoperation has been needed in 6 patients.

In 2 of these patients it has been necessary to reoperate twice and in 1 three times. This last patient, always an anxious woman, was reduced to a psychological cripple by her pacemaker problems. At the last operation the unit was replaced by a totally implanted type of pacemaker, with improvement in her mental state. At all reoperations it has fortunately been possible to use the same vein for catheter reinsertion when this has been necessary.

Causes for reoperation have been as follows.

(1) Catheter slipping into the right atrium three times. This complication occurred relatively early after catheter insertion (1, 7, and 14 days).

(2) Catheter in the coronary sinus twice.
On one occasion the catheter was mispositioned originally and required reoperation at 7 days. In the other there is *x*-ray confirmation of original correct ventricular siting, and migration to the coronary sinus did not occur until after three months.

(3) Catheter slipping into the outflow tract once.
This was noted very shortly after insertion but pacing did not become erratic until three months had elapsed.

(4) Poor ventricular contact caused by body movement once.
Surprisingly this did not occur until after six months. At reoperation the catheter was noted to be unusually mobile in the vein without any of the fibrous tissue reaction usually noted at its junction to the coil.

(5) Internal insulation problems probably twice.
One patient began to respond to high power only at two weeks; the other at three months. At exploration no cause was found in either patient and the whole internal unit was replaced. Subsequent examination of the second replaced unit showed an insulation leak at the catheter coil junction.

Neither sepsis nor wire fracture has occurred in any patient, and the most troublesome minor problem with this method has been muscle twitch from the indifferent electrode. This has occurred 10 times in 9 patients despite careful siting of the electrode and testing for it at operation. In 2 patients it has caused considerable discomfort: and in one of these, previously mentioned as a pacemaker-induced psychological cripple, its appearance was the deciding factor in changing to a totally implanted system. In all other instances it has been possible to reduce the twitch to tolerable levels without reoperation. This is commonly achieved by off-centering the external coil, which is safe provided such off-centering does not approach the critical point where pacing becomes intermittent.

Overall mean patient survival at present stands at 8·1 months as compared with a mean internal unit survival of 6·3 months.

Discussion

Comparison of epicardial wires and endocardial catheters within the Lucas system It is not possible to draw any valid conclusions from this series about the long-term mortality of the two groups of patients. In the short term there is no doubt that patients undergoing thoracotomy for the insertion of epicardial wires had a greater mortality ($p < 0.05$) than those undergoing the simpler surgical procedures involved in catheter coil insertion. Most patients with chronic heart block are elderly and do not withstand thoracotomy well, being particularly prone to the chest and embolic complications of this major operation. This difference in postoperative mortality is in agreement with the findings of others and particularly those of Harris *et al.* (1965). From a practical standpoint it means that many patients can now be pacemade who would previously have been refused operation on grounds of age or infirmity.

Siddons and Sowton (1967) suggest that a proportion of sudden (and therefore presumed arrhythmic) deaths are directly attributable to the thoracotomy. The findings of this series support this suggestion though the numbers are small. The situation is complicated by the knowledge that certainly in one, and possibly in another, patient dying from arrhythmia after thoracotomy the pacemaker was on high power, with the attendant approximation of stimulation voltage to ventricular fibrillation threshold. This threshold is almost certainly reduced after operation. There are many factors operative at this time, but hypoxia and hypercarbia provoked by pain on breathing and by the drugs given to relieve this pain must be relevant. The myocardial trauma produced by insertion of wires at thoracotomy must provoke injury currents and these have been shown to initiate arrhythmias (Hoffman, Cranefield, and Wallace, 1966). It is of interest that the only endocardial patient dying from arrhythmia in this series should have sustained a catheter perforation of the myocardium.

On the other hand, the need for reoperation occurred more frequently in those patients not subjected to thoracotomy. This is particularly shown by comparison between mean patient and mean internal unit survival times

for the two groups. There is little difference between these two figures for thoracotomy patients (24·0 versus 22·9 months, respectively) but for catheter-paced patients the figure difference is relatively large (8·1 versus 6·3 months). Reoperation in this group was mainly caused by the catheter being badly sited and usually occurred early. However, in 2 patients these problems occurred after some months' satisfactory pacing, and in one of them the catheter migrated from the ventricle to the atrium to the coronary sinus. This seems to be unique.

McNally and Benchimol (1968) state that electrode displacement is probably the major drawback of endocardial type pacing and has certainly been the major cause of failure in this series. However, insulation problems also caused two failures and the attractively simple push-pull fit between catheter and internal coil may be a weak point in the Lucas system, particularly if the catheter is not cleanly cut when shortening. Wire fracture has not been proved with either system. The helical catheter construction has good stress resistance *in vitro* and has proved very satisfactory elsewhere (Abrams, 1969), but has been insufficiently tested in this series.

Muscle twitch from the indifferent electrode of the endocardial system has been of quite considerable nuisance value (neither superficial nor diaphragmatic twitch has occurred with epicardial wires). This twitch seems to take two forms. Even without muscle relaxants the 'twitch threshold' seems to be higher under general anaesthetic. In heavily muscled men in whom it has been difficult to find a good position for the indifferent electrode it has not been uncommon to find twitch the next day. In some other cases twitch developed and increased in severity some weeks after discharge from hospital. It is felt that this predisposition to muscle twitch is a design fault in the system. The indifferent electrode is a simple loop to be sutured on or into periosteum from which muscle fibres arise. It is of small surface area and thereby carries a high relative current density. It seems more logical that it be of larger surface area and backed by insulating material in order to face toward subcutaneous tissue. Indeed, for operating simplicity, it might be a backed circular disc situated within the internal coil itself.

Comparison of induction and totally implanted pacemakers McNally and Benchimol (1968) have stated that the prerequisite for a permanent pacemaker to which all other considerations are secondary is reliability. The same prime consideration has been differently stated by Norman, Lightwood, and Abrams (1964) in that the system should have simplicity of electronic design and a minimum number of internal components. They also considered that other important considerations were that there be complete control of pulse stimulus (rate, duration, and strength) and that the system be compact. Since there now seems good evidence that competition between artificially paced and natural cardiac rhythms is dangerous (Sowton, 1965; Bilitch, 1969), the system should be capable of providing protection from such competition when necessary and without prejudice to reliability. It should also be protected against extraneous external signals (i.e. radio waves and electrical currents). Lastly, it should be cheap to install and maintain, unaffected by environmental conditions, and provide complete mental reassurance to its user without physical discomfort.

Since reliability is of paramount importance, it is obviously advantageous to have those components of the pacemaker most liable to failure situated outside the body. In the early days of pacemaking this was achieved by means of wires from the heart passing through the skin to an external pacemaker. Such a long-term method is no longer acceptable in view of the risk of sepsis. The Lucas system avoids the necessity for any wire to cross the intact skin while situating those components liable to failure outside the body where they are readily accessible. The implanted coil is simple in design and does not fail. The external generator and its leads are not specially reliable but have no need to be so in view of immediate and audible warning of sudden failure. All patients leave hospital with one spare generator and two spare leads and have time in emergency to make the necessary rapid adjustments to restart pacing. (It should be stated that this audible warning only occurs when the generator is set at 'TICK' and in our opinion this is a fault in design.)

An attractive feature of the Lucas system is its battery and the way this is used. As has been pointed out by Taylor (1966), the U2 torch battery is readily available everywhere and will last a month if necessary. As the battery is discharged pacemaker rate slows while maintaining voltage constant. Thus the patient himself has a ready check on remaining battery life according to advancement of the rate control disc.

By comparison, totally implanted units do not have the same degree of overall reliability. Parsonnet *et al.* (1970) state that most of these

pacemakers must be changed (by reoperation) within two years and they themselves using various makes have experienced a 50 per cent failure rate in 20 months. This compares with a 9 per cent internal unit failure rate after 24 months in the patients of this series pacemade by thoracotomy – many of whom have paced satisfactorily without reoperation for more than three years. The figures for catheter coils in this series are not so satisfactory (40 operations in 30 patients), but in only three reoperations has the fault not been attributable to faulty catheter siting. These findings are in agreement with those of Abrams (1969) who concludes that inductively coupled pacemaking provides safe pacemaking for long periods of time without the need for secondary reoperation.

Of course, very many of the reoperations necessary with totally implanted units are because of battery failure. Unfortunately, the makers' expectations of battery life are not individually reliable. The American Association of Medical Instrumentation has suggested that such pacemakers be designed to signal impending battery failure by a slowing of the impulse discharge rate, but there is still much variation in behaviour from one make to another. It is a sad reflection on the generally unsatisfactory methods available to detect battery failure that there are so many different methods suggested. This is partly the result of non-standardization between different manufacturers, but it certainly leads to the necessity for setting up special pacemaker clinics with expensive apparatus and highly trained personnel. By contrast, no special pacemaker clinic is necessary with the Lucas system and such patients are simply followed in the general cardiological clinics.

If one considers control of pulse stimulus to be important, the Lucas system is once again at an advantage with its external controls. However, the situation is not straightforward. Patients with a fixed heart rate can vary cardiac output by alteration in stroke volume. Obviously they cannot achieve the cardiac outputs obtainable with a normally variable heart rate and it might seem attractive to be able to vary heart rate to augment output as the situation demanded. Unfortunately, many patients with heart block have severe myocardial disease and it has been shown (McNally and Benchimol, 1968) that in such patients cardiac output actually falls with alteration in rate from an optimum level of about 80. A minority of blocked patients do achieve considerable increase in output with increase of rate on exercise. Unfortunately they can only be distinguished from the majority, in whom there is little increase, by special haemodynamic studies too time consuming to be valuable.

Abrams (1969) cites two patients in whom episodes of tachycardia could be suppressed by rapid rate pacemaking between 90 and 115 impulses/min. Maintained rapid rate pacemaking certainly is a theoretical advantage of any system with external controls, albeit that the necessity for its use will be infrequent. Our own experience of one case was less satisfactory. A rate of 110 did successfully suppress the ectopic focus giving rise to intermittent ventricular tachycardia. Unfortunately to maintain this rate the external controls required approximately 6-hourly adjustments when the battery was pristine and more frequent still after some 36 hours of battery use. This disadvantage precluded the patient's discharge from hospital for some weeks.

Pulse duration can be fairly simply altered in the Lucas system by changing the number of turns in the winding of the external coil. Lengthening pulse width up to about 10 msec has been found to reduce pacing thresholds (Marchand, Jaros, and Obel, 1969), but Zoll and Linenthal (1964) state that when pulse width is increased from 5 to 20 msec in dogs the normal safety factor between ventricular fibrillation and pacing thresholds is reduced. Normal pulse width with the Lucas system is 1 msec. This is of very adequate duration to stimulate the ventricle, and with external batteries there is no advantage in increasing it to prolong battery life. We have found that widening the impulse to 2 msec was useful in diminishing muscle twitch on one occasion.

It will be seen from Fig. 2 that the voltage waveform over this 1 msec is in the shape of a biphasic sine wave with approximately similar curve areas above and below zero. Since the indifferent electrode in the system is made of stainless steel, and not of a noble metal, such balanced voltages are important to prevent electrolysis. It is interesting to note that the indifferent electrode is not always positive as in other systems. Indeed, its initial polarity depends upon how the lead is plugged from the external coil to the generator. As yet we know of no practical implications from this fact.

The ability to change to a higher voltage is a definite, but limited, advantage of the system. In certain emergencies high power can be invaluable while making relatively unhurried preparations to replace internal units. These situations have not been uncommon and include exit block, coronary sinus pacing, and insulation failure. A practical but definite dis-

advantage of other than temporary high power pacing in patients with endocardial catheters is the almost universal appearance of muscle twitch.

Fig. 2 also shows that the voltage transmitted to the heart is dependent upon the separation of the two coils. This separation is largely determined by skin and subcutaneous tissue thickness, but even at 1 cm separation (often less in practice), and on low power, the maximum voltage delivered is in excess of 5 volts. In general, the energy delivered from this system to the heart is greater than with most totally implanted types of pacemaker. Much energy is wasted at induction, but with external batteries this is not important. There is controversy as to whether the pacing stimulus itself causes myocardial damage, the degree being dependent upon the current density delivered (Marchand *et al.*, 1969). Zoll *et al.* (1961) believe it does not and, if they are correct, there is an obvious advantage in delivering a greater stimulating voltage to the heart provided ventricular fibrillation is not provoked.

Ventricular fibrillation does not occur with the voltages and currents used in any normally functioning commercially available pacemaker unless impulses fall in the so-called vulnerable period of diastole. The normal safety margin between pacing and fibrillatory thresholds for such impulses is large but can momentarily be exceeded by the Lucas system on high power. In patients with myocardial disease this safety factor is reduced and can certainly be exceeded by any commercially available pacemaker. As stated, the Lucas system does deliver more voltage to the heart than most other systems, even on low power. This is an advantage provided that paced rhythm is not being interfered with either by ectopic beats or by parasystole allowing impulses to fall in the vulnerable period. Other manufacturers provide demand models for use in these situations but these have the disadvantage of more and complicated electronic circuitry to fail. A demand mode is theoretically possible with the Lucas system, but the resulting pacemaker is too cumbersome and expensive for any but research use. In this series of 64 patients, parasystole has been observed at one time or another in 15, 3 of whom have died from presumed arrhythmia. Abrams (1969) has suggested that such parasystolic patients should be paced either with a slow rate if they have long periods of sinus rhythm, or alternatively at a fast rate if the arrhythmia is more variable. It is felt that the first suggestion is dangerous and it is our practice to administer beta-adrenergic blocking drugs to both types of patients and to increase the rate where necessary to achieve suppression. These drugs have the added advantage of raising the fibrillation threshold, but a theoretical disadvantage in also raising the pacing threshold. In practice this has never been a problem.

Inductive systems of pacemaking give good protection against extraneous external signals – being unaffected by direct current countershock or by extraneous radio signals. The situation with totally implanted units is variable from model to model and since these 'radio' signals take a number of forms other than the obvious, i.e. proximity to neon advertising lights, diathermy machines, sparking plugs, ultraviolet light machines, and others, and provoke ventricular fibrillation, the situation is important. However, it is only fair to say that since Lichter, Borrie, and Miller (1965) pointed out these dangers most manufacturers have altered the design of their models where necessary. Nevertheless, protection against DC shock remains an advantage of the Lucas system, many other pacemakers being totally disabled by it.

The cost of providing a pacemaking service in this country is expensive. Sowton (1968), who uses only implantable models, estimates that approximately £12 to £16 a month will need to be budgeted for every patient, even if one only considers pacemaker cost and time spent in hospital. Even though a patient leaves hospital with two complete external units, the cost of the Lucas pacemaker itself per patient is only some two-thirds that of the cheapest implantable unit. However, most patients will require a spare generator every 4 to 6 months and the actual cost works out very little different for this pacemaker. The Lucas system is at an advantage, however, in that the patient spends less time in hospital for reoperations and that there is no necessity to set up expensive pacemaker clinics.

Thus far it seems that the Lucas system offers advantages, particularly in terms of reliability. Unfortunately it is not perfect. The external generator is cumbersome and the lead to it from the external coil is liable to fracture. A new model is promised in which the external generator will be strapped directly over the internal coil. This will be an improvement, but other problems remain.

The system is not suitable for use in hot climatic conditions. Even in this country many patients complain of minor skin excoriation between the rings though sepsis or skin breakage are rare. Reactions to the necessary strapping were a nuisance but are now uncommon using 'Micropore' tape. Unfortu-

nately this tape is expensive and difficult to obtain by normal prescription. The external coil is water-protected but not waterproof, and some patients find it difficult to maintain a personally acceptable state of hygiene around and under the coil.

In several patients blindness or infirmity has prevented the patient from being able to manage the pacemaker himself. Surprisingly this has not been a problem even in one man who is too unintelligent to have been aware of having sustained Adams-Stokes attacks. Day-to-day supervision has readily been undertaken by relatives or neighbours in these cases with the very competent backing of the district nursing service.

The major drawback of this system is psychological. Theoretically it is possible to preach to every patient about its reliability and other advantages. Unfortunately all these advantages are dependent upon the generator and batteries being external. It is true that a few intelligent patients can understand and even prefer such a system and that most patients do come to regard the pacemaker and its external controls as part of their everyday life. Nevertheless, the presence of an external unit does serve to remind the patient unceasingly of his dependence upon it. For a patient of nervous disposition this can be an intolerable burden. In this series 8 patients (2 men, 6 women) were, in retrospect, not suitable for such a pacemaker on psychological grounds. One patient successfully committed suicide because of an obsession about pacemaker failure and another attempted it by throwing away the external generator. A third spends a large part of her day making minute and totally unnecessary adjustments. The remainder require constant and unaccepted reassurance, returning unit after unit for undetectable faults and often living the lives of semi-invalids at home. It will be interesting to see how these patients will react to the rather less cumbersome and obtrusive model promised in the near future.

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